Obviously the conditions in Bent Creek Valley are common to all like valleys and coves in the mountainous region whose floors have a gentle slope, and are dominated by a larger valley system. Coves on steeply sloping mountain sides are not frost pockets since cold air drains out as fast as it accumulates. The direction in which the valley extends undoubtedly has a direct bearing upon the diurnal changes; inversions probably develop more quickly in those having a north-south axis than in those opening toward the western sun. Variations in the extent of inversions in mountain valleys and coves, and in the rates of their formation and dispersal are well-nigh infinite.

This study is far from exhaustive, even for this particular valley, but it serves to throw light upon the changes in temperature which take place in similar valleys. If stations had been located in different portions of this valley they undoubtedly would have yielded slightly different results, but it is certain that those differences would have been quantitative rather than qualitative.

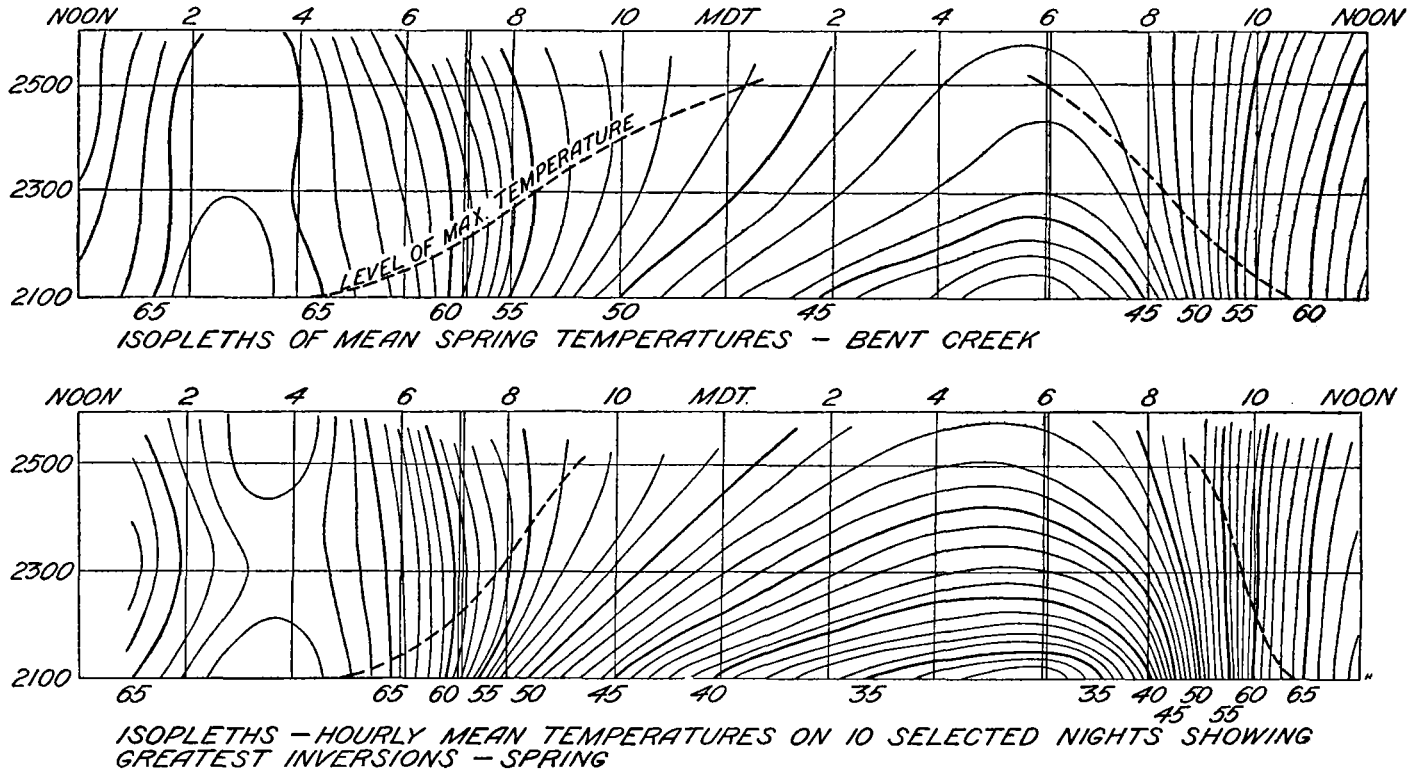

FIGURE 6.—Upper: Isopleths of mean spring temperatures, Bent Creek. Lower: Isopleths, hourly mean temperatures on 10 selected nights showing greatest inversions—spring.

THE GREAT DUSTSTORM OF NOVEMBER 12, 1933

By M. R. HOVDE

[Weather Bureau Office, Huron, S.Dak.]

In the climatological reports of the Great Plains will be found many accounts of severe dust and sandstorms. The MONTHLY WEATHER REVIEW has published narratives and articles concerning the outstanding storms of this nature. The duration and severity of duststorms depend on (1) the type of storm; (2) the covering of the soil, whether bare or vegetated; (3) the rainfall preceding the storm, or water content of the surface.

The whirlwind type (thunderstorms, tornadoes, and whirlwinds) may cause duststorms over limited areas only and their duration is short, in keeping with the characteristics of these local disturbances.

In the shift-wind type one refers to the area of low pressure with a characteristic trough and wind-shift line. In nature's effort to restore equilibrium, winds of gale force may raise dust along the wind-shift line.

The third type may be called the straight-wind type. Such a type calls for an area of high pressure and steep barometric gradient, which occurs only near the forward border of such area.

In the great duststorm of Sunday, November 12, 1933, the third or straight-wind type prevailed. This duststorm probably covered the greatest area of recent sandstorms, involving the vast territory from the Canadian line—Lake Superior to Montana—southward to the western Ohio and lower Missouri Valleys, a region of greater extent than the combined areas of France, Italy, and Hungary. Over South Dakota the dirtstorm was the severest within the memory of old settlers and cooperative observers. In adjoining States the prevalence of dust varied according to surface protection by vegetation or recent precipitation. The northern portions of Minnesota and North Dakota had a light snow layer and during the storm received precipitation which reduced the dust annoyance to a great extent. In Iowa the high winds blew much corn from the stalks, visibility was low and artificial lights were required during the day. Flying schedules on the airways into the Dakotas and Manitoba, Canada, were canceled.

The morning map of the 11th revealed a disturbance moving rapidly southeastward over Alberta, Fairview, 29.60 inches, and the anticyclone was centered at Boise, Idaho, 30.54 inches. On the morning of the 12th the Alberta storm reached southern Manitoba, Canada,

Pembina, N.Dak., 29.24 inches, while the anticyclone remained stationary and maintained a somewhat greater intensity over Idaho and Washington, Spokane, Wash., 30.60 inches.

This gradient was sufficient to cause winds of gale force over the northern and central Great Plains. Owing to severe drought all crops, including pasture grass and hay, had failed over vast areas in South Dakota, a condition that served to accentuate the dense clouds of dirt and dust. In table 1 wind velocities are given for widely scattered stations.

TABLE 1.—*Maxima wind velocities for periods during the day (m.p.h. and C.S.T.)*

Station	7 to 10 a.m.	10 a.m. to 1 p.m.	1 to 4 p.m.	4 to 7 p.m.	Extreme velocity
Williston, N.Dak.	46	38	21	11	53
Bismarck, N.Dak.	50	46	35	25	56
Devils Lake, N.Dak.	40	35	34	29	41
Fargo Airport, N.Dak.	50	46	45	45	----
Duluth, Minn.	21	22	38	41	44
Pembina, N.Dak.	47	47	37	30	----
Rapid City, S.Dak.	41	37	35	30	44
Huron, S.Dak.	45	44	37	27	51
Alexandria, Minn.	34	42	48	35	----
Minneapolis, Minn.	34	38	41	36	46
Valentine, Nebr.	31	35	37	34	48
Sioux City, Iowa.	32	43	46	43	51
Davenport, Iowa.	30	34	40	[1] 43	[2] 56
Kansas City, Mo.	21	24	27	35	40

[1] 7:29 p.m. [2] 7:31 p.m.

The picture of the awe-inspiring storm becomes more impressive when the following facts of soil moisture and surface water content are visualized. The less than 8 inches of rain in the 5 months preceding the storm (see table 2), coupled with the fact that June was the hottest of record and July a near record breaker for heat, necessitated that drought and extreme dryness be prevalent.

TABLE 2.—*Average precipitation and temperature for South Dakota, 1933 (95 stations)*

Month	Precipitation	Departure	Temperature	Departure
June	1.48	−2.07	76.5	+10.0
July	2.34	−.29	77.5	+5.0
August	2.35	+.02	70.3	−.1
September	1.21	−.48	66.7	+5.2
October	.12	−1.19	49.3	+.9
November 1-12	.13	−.16	----	----
Total	7.63	−4.17	----	----

The visibility data are interesting and testify to the severity of the storm and the obstruction to vision. The reports reveal a remarkable precedent of zero visibility at distant points caused only by a dust-laden atmosphere. In table 3, the visibility is given for selected hours throughout the daytime from widely scattered stations. With the eastward drift of the storm, it naturally followed that low visibility was reached late in the day at the more eastern stations.

The usual manifestations of atmospheric electricity are lightning, the aurora, and St. Elmo's fire, but on this date there were other evidences of a charged atmosphere. Farmers received shocks when closing the standard pasture gate (barbed wire and small posts); telephone poles (not power lines) were burned and charred; power lines were troubled; automobiles stalled; and radio aerials crackled.

Houses, well built with tight windows, weather-stripped and with storm sash, could not keep out the unwelcome entrance of fine, powderlike dust. Every home and building had to be cleaned from basement to roof.

TABLE 3.—*Visibility (miles and fractions) C.S.T.*

Station	7 a.m.	10:30 a.m.	Local noon	2:30 p.m.	7 p.m.	Lowest any time
Bismarck	12	4	4	5	6	3
Devils Lake	3	3	3	2	8	2
Moorhead	10	1	½	½	10	½
Duluth	12	10	1	7	12	1
Pembina	5	0	0	¼	1	Zero
Huron	10	⅛	0	¼	2	Zero
Alexandria, Minn.	8	2	½	¼	1	Zero
St. Paul	10	7	4	1	1	1
Valentine	4	½	½	¼	4	½
Sioux City	15	¾	¼	0	¼	Zero
Adair, Iowa	12	10	2	½	⅛	⅛
Davenport	8	8	8	2½	½	½
Kansas City	12	12	12	12	1	1

The damage by wind, dust, and electrical discharges over the several States will never be ascertained. For South Dakota the loss is estimated to be several millions of dollars, for one must take into account the structural damage to buildings, leveling of fences, the scattering of hay and fodder stacks, the damage to highways, soil erosion, and injury to winter crops.

Spectacular becomes a weak adjective when applied to this storm. It was awful, terrifying—the howling winds and a darkness that turned the midday into night, will never be forgotten by residents of the State.

COMMENTS FROM WEATHER BUREAU STATIONS

Bismarck.—We had a maximum wind velocity of 50 miles per hour on Sunday forenoon and considerable damage resulted in this vicinity.

Kansas City.—This storm did not arrive here until late in the afternoon of the 12th. Dust first observed by airport observers about 3:30 p.m. It became thicker late in the evening; the lowest visibility occurring at about 9:30 p.m. when it was about three fourths of a mile.

Valentine.—The total precipitation at Valentine from August 29 to November 12 was 0.53 inch. One moment I could see an object about one half mile away and in another moment could not see it. Occasional breaks of 1 or 2 seconds in the dust clouds indicated a clear sky but dense dust obscured the sun.

Des Moines.—A gale and intense dust storm on the 12th made lights necessary in houses and on automobiles in the midafternoon. Corn shocks were blown over and straw stacks damaged; considerable wheat was blown out or covered. Fall-plowed soil drifted. Damage occurred to buildings and trees. Half the corn was blown onto the ground making it impracticable to use husking machines.

Minneapolis.—High winds Sunday, November 12, 1933, caused considerable damage and much soil blowing in the south portion of the State.

Lincoln.—The weather continued dry, with gales of dense dust Sunday, November 12, 1933.

Sioux City.—The horizontal visibility decreased from 15 miles at 7 a.m. to one fourth mile at 12:26 p.m. The ceiling and visibility were both recorded as zero at 2:30 p.m. when objects could not be seen by pedestrians at a distance greater than 50 feet. Obstruction to vision of 100 feet or less obtained from 1 p.m. to 3 p.m. when houses and buildings were artificially lighted. At 6:45 p.m. the visibility was one fourth mile, following which there was a gradual improvement and by 10:30 p.m. it was extended to 8 miles.